# Comparative Study Of Fastness Properties And Color Absorbance Criteria Of Conventional And Avitera Reactive Dyeing On Cotton Knit Fabric

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doi: 10.19044/esj.2016.v12n15p352 URL:http://dx.doi.org/10.19044/esj.2016.v12n15p352

**Abstract**

160 GSM Single Jersey cotton knitted fabric was dyed with conventional Remazol reactive dye and latest Avitera reactive dye (Huntsman). Detailed comparison of the process parameters and fastness properties of these dyed fabrics were studied. Investigation exposed that Avitera delivered better dyeing performance including fastness to washing, perspiration, rubbing than conventionally dyed fabrics. Concerning process parameters Avitera dye required less soda, salt and no addition of other auxiliaries. Also this new Avitera reactive dye is more eco-friendly, cost effective and energy saving than conventional Remazol reactive dye. CMC DE and Da* color deviation were significantly higher between the dyed samples. Again K/S value of Avitera dyed sample was superior to that of Remazol dyed samples as because of enhanced dye uptake. Sequentially reflectance and relative indicators of the latest reactive dyed samples were also experimented.

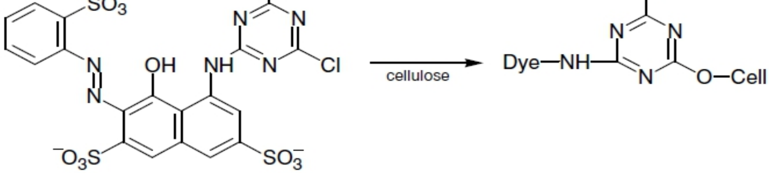
**Keywords:** Avitera reactive dye, Remazol reactive dye, Color Fastness, Energy saving, K/S value, CMC DE, Reflectance.

**Introduction:**

The best dyes to apply on cotton fabric and other cellulose fibers are reactive dyes. They are much brighter, longer-lasting, and easier-to-use than all-purpose dyes. Specialists bear in mind about taking new methods for improving the dye ability of cellulose fibers with reactive dye (Lewis, D.M. 1991) day by day. Avitera, introduced by Huntsman, is the latest addition of reactive dyes which is highly soluble. In exhaust dyeing processes, Avitera is applied on cellulose fibers at lower temperature than 60°C, using short dyeing and washing-off cycles, enabling low water and energy saving process for cotton (Presˇa P, 2009). These dyes may be used in ultra-short liquor ratios, and offer lab-to-bulk and bulk-to-bulk shade reproducibility. All primaries yellow, red and blue are available for offering suitable medium to dark shades. These dyes are compatible with its Gentle Power Bleach pretreatment system, which features enzyme technology capable of low-temperature bleaching at a neutral pH. This technology with low liquor ratio allows water and energy savings of 50% and thus lower processing costs, with high-quality and improved environmental sustainability in textile processing. Predominantly Avitera dyes are found with dominating character like environment friendly since it needs a small amount of chemicals. Nearly ninety percent of the dye applied to cotton during dyeing is fixed, as opposed to 60 to 80 percent with conventional reactive dyes (textiletoday, 2011). Three basic steps involves in reactive dyeing are: exhaustion of the dye from an aqueous bath containing common salt or Glauber salt normally under neutral condition (pH – 7); addition of an alkali to promote to further dye uptake and chemical reaction of absorbed dye with the fiber and Dyed material is then rinsed and soaped to remove electrolyte, alkali and unfixed dye. The dyes are in most cases readily water-soluble. They are dissolved either by passing with cold water to which is added hot water or by strewing the dye powder into hot water which is stirred at high speed. Usually a temperature not greater than 80ºC is used for dissolution. In the case of highly reactive dyes such as Procion MX (ICI) warm (50º-60ºC) water is used. Since the dyes are prone to hydrolysis stock solutions should not be stored for long periods. Reactive dyes form covalent bond with cellulose fiber by Nucleophilic substitution and addition reactions. The molecular structures of reactive dyes resemble those of acid and simple direct cotton dyes, but with an added reactive group (Arthur D Broadbent, 2001). The reactions are as follows -----

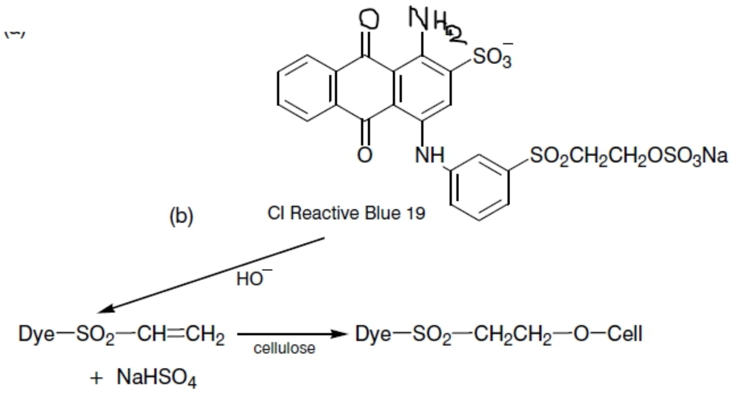
**Substitution reaction:**

$$D – R – Cl \quad + \quad HO - Cell \rightarrow D – R – O – Cell \quad + \quad HCl$$



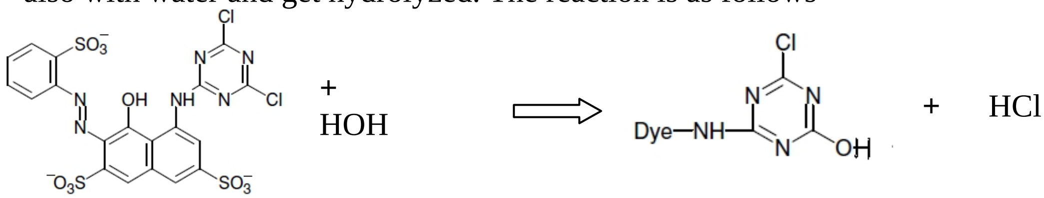

Scheme 1: CI Reactive Red 1 bonded with cellulose by substitution reaction

**Addition reaction:**




Scheme 2: Cellulose bonded with Reactive Dye by addition reaction

The cold brand reactive dyes are highly reactive in nature. They react also with water and get hydrolyzed. The reaction is as follows ----




Scheme 3: Hydrolysis of Reactive dye

The hydrolyzed dye is also colored substances and has very low substantivity for the cellulose fiber. So they are attached with fiber surface after dyeing. If they do not washed away from the fiber surface the fastness property of the fiber must be very low.

**Materials and Methods:**

- 160 GSM S/J knit fabric (Pure white cotton), sample weight:10gm
- Reactive dye brand: AVITERA SE (primary color)

Table 1: Recipe for different % of shade

| Shade% / Auxiliaries | 0.5% | 1% | 1.2% |
|---|---|---|---|
| Glauber Salt | 30 g/l | 40 g/l | 40 g/l |
| Soda Ash | 8 g/l | 10 g/l | 10 g/l |

**Pretreatment**

Scouring is the process by which all natural and adventitious impurities such as oil, wax, fat etc are removed to produce hydrophilic and clean textile material. It is the vital process of wet processing. Bleaching of textile material is a commercial process which can be defined as- destruction of natural coloring matters to impart pure permanent and basic white effects suitable for the production of white finishes, level dyeing and desired printed shade with the minimum or no tendering or without diminishing the tensile strength.

Recipe of pretreatment:

| | |
|---|---|
| NaOH | : 5 g/l |
| H2O2 | : 5 g/l |
| Wetting Agent | : 1.5g/l |
| Sequestering Agent | : 1.5g/l |
| Stabilizer | : 1.5g/l |
| M: L | : 1:10 |
| Temp | : 105°C |
| Time | : 60' |

**Dyeing Procedure at different parameters:**

Program 1 for Infrared lab dyeing m/c

| | | |
|---|---|---|
| Step (1) | 40° | -start |
| Step (2) | 40°-60° | -5 ' run time |
| Step (3) | 60° | -10' color dosing |
| Step (4) | 60° | - 10' run time |
| Step (5) | 60° | -5 ' [Salt dosing] |
| Step (6) | 60° | -5 ' run time |
| Step (7) | 60° | -10' soda dosing |
| Step (8) | 60° | -10 ' run time |
| Step (9) | 60°-40° | -5 ' |

Program-2 for Infrared lab dyeing m/c

| | | |
|---|---|---|
| Step (1) | 60° | -Start |
| Step (2) | 60° | -10 ' color dosing |
| Step (3) | 60° | -5 ' run |
| Step (4) | 60° | -5 ' [Salt dosing] |
| Step (5) | 60 | - 5 ' run |
| Step (6) | 60° | - 10 ' [soda dosing] |
| Step (7) | 60° | - 5' run time |

**Dyeing Curve 1:**

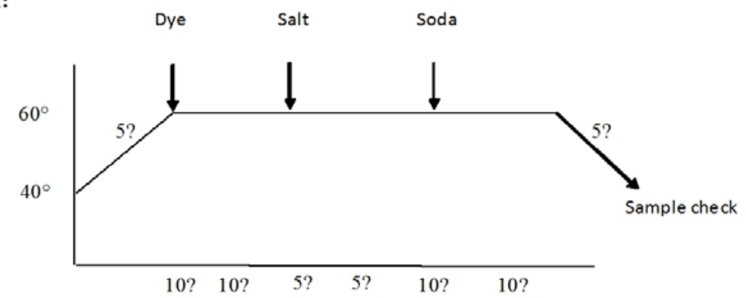



Fig 1: Dyeing curve maintained for Reactive dyeing of cellulose, program:1

**Dyeing Curve 2:**

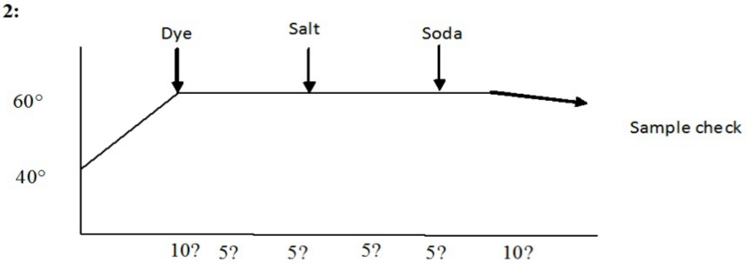



Fig 2: Dyeing curve maintained for Reactive dyeing of cellulose, program:2

## Reactive Dyeing Process

The dyeing process takes place in three distinct phases. i) Adsorption and Diffusion: The reactive dye is adsorbed onto the cellulose surface and then diffuses into the fiber matrix. ii) Fixation: If conditions are favorable (high temperature and/or high pH), the reactive dye reacts with active sites in the cellulose during this phase (fixation), resulting in a strong covalent bond. iii) Washing Off: To obtain the required fastness properties, all these forms of unfixed, adsorbed dye molecules must be washed off from the fiber. Industrial practice has shown that with AVITERA SE, nearly 90 percent of the dye applied are successfully attached to cotton. Hot dyeing systems require a temperature of 176°F (80°C) to make the bond between dyestuff and fabric permanent. These systems also require boiling water and several rinsing baths to completely remove unfixed dyestuffs.

## Color fastness to washing

The ability of a dyed fabric to retain its original shade against fade during washing is called color fastness to wash.

Recipe:

| | |
|---|---|
| 1) Anhydrous Sodium Carbonate | : 2g/l |
| 2) ISO Standard Soap | : 5g/l |
| 3) M: L | : 1:50 |
| 4) Temp | : 60°C |
| 5) Time | : 30 min |
| 5) Sample weight | : Average 1.3g |

## Color fastness to perspiration

This method is intended for the determination of the resistance of the color of textiles of all kind and in all forms to perspiration from the human body which is a complex chemical containing large quantities of salt, depending on the human metabolism. It can be either acidic or alkali. Most of the tests for fastness to perspiration are based on a solution containing the chemical Histadine.

Two types of solutions are used: a) Alkaline Solution and b) Acidic Solution

For alkaline solution:

Recipe:

| | |
|---|---|
| 1) Hydrochloride monohydrate (98%) | :0.5g/l |
| 2) Disodium hydrogen orthophosphate Dehydrate ($Na_2HPO_4.2H_20$) | :2.5g/l |
| 3) Sodium Chloride (NaCl) | : 5g/l |
| 4) Time | : 4hrs. |
| 5) Temp | : 37°C |
| 6) Sample size | : 10×4 |
| 7) pH | : 8 |

## Color Fastness to Rubbing

Fastness to rubbing is used to ensure that fabric doesn't transfer their color when rubbed against another layer of fabric or material this test is also known as crocking and is carried out using a crock meter .rubbing fastness is carried out with either a dry or wet cotton fabric that is rubbed against the surface of the dyed fabric to remove unfixed dye stuff .Rubbing fastness using a wet test fabric tends to show higher color transfer then when using a dry test fabric.

Two Types
a) Dry rubbing,
b) Wet rubbing

| | |
|---|---|
| Sample size | : 20cm×5cm |
| Crock fabric (White) | : 5cm×5cm |
| No. of rotation | : 10 cycle |
| Time | : 10 sec |

## Determination of CMC value

Color Measurement Committee is an ideal choice for a computerized pass/fail program. As the region of color space changes, the size of the ellipse changes with regard to visual perception, but the $\Delta E_{CMC}$ remains 1.0. It is therefore possible to use a single value for 〖ΔE〗_CMC as a pass/fail tolerance for all shades. CMC is not a color space but rather a tolerancing system. CMC tolerancing is based on CIELCH and provides better agreement between visual assessment and measured color difference. CMC tolerancing was developed by the Colour Measurement Committee of the Society of Dyers and Colourists in Great Britain and became public domain in 1988.The CMC calculation mathematically defines an ellipsoid around the standard color with semi-axis corresponding to hue, chroma and lightness.CMC is a tolerancing system, which provided better agreement between visual assessment and instrumentally measured color difference. CIE 1976 L*a*b* (CIELAB) is color scales based on the Opponent- Color Theory.

L scale: Light vs. dark where a low number (0-50) indicates dark and a high number (51-100) indicates light. a scale: Red vs. green where a positive number indicates red and a negative number indicates green. b scale: Yellow vs. blue where a positive number indicates yellow and a negative number indicates blue. The L value for each scale therefore indicates the level of light or dark, the value redness or greenness, and the b value yellowness or blueness. All three values are required to completely describe an object‘s color. A three-dimensional representation of L, a, b color space (Xrite, 2012).

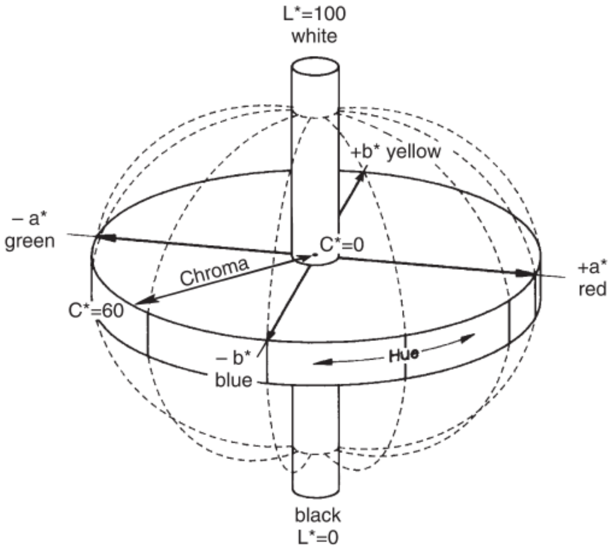



Fig 3: Schematic figure of CIE Lab color theory

Figure 3 shows the L* value is represented on the center axis .the a* and b* axes appear on the horizontal plane.

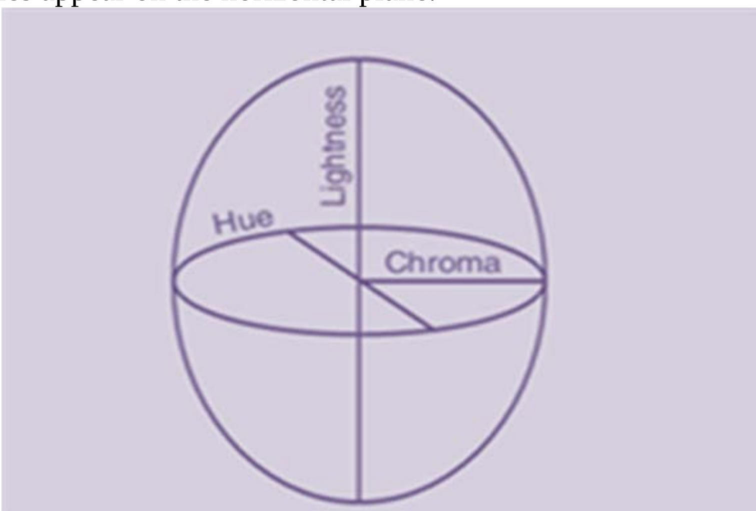



Fig 4: Hue, value and chroma direction in CIE LCH theory

**Measurement of Reflectance value(R) %**

Spectrophotometric measurement provides the numerical description of the reflection or transmission of light by an object. The reflectance or transmission spectrum gives the fraction of the incident light that an object reflects or transmits as a function of wavelength. For particular wavelength it has linear relationship.

## Determination of K/S Value

For a mixture of a number i of colorant in a sample the global kubelka-Munk value at a given wavelength is:

$$\frac{K}{S} = \frac{K_t + \sum(K_i C_i)}{S_t + \sum(S_i C_i)} = \frac{(1 - R_\infty)^2}{2R_\infty}$$

Where K and S are the absorption and scattering coefficients of the various dyes (i) and of the un-dyed textile material(t).$C\_i$ is the concentration of each colorant. $R\_\infty$ is the reflectance .So the global value of K/S for the dyed textile then becomes a linear function of the amounts of colorants present in the sample fabric.

## Results and Discussions:

Table 2: Assessment color fastness to wash for 60° 40 '

| Shade% | Di acetate | Bleached cotton | Polyamide | Polyester | Acrylic | Wool |
|---|---|---|---|---|---|---|
| 0.5% | 4/5 | 4/5 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.0% | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.2% | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |

Table 3: Assessment color fastness to wash for 60° 60 '

| Shade% | Diacetate | Bleached cotton | Polyamide | Polyester | Acrylic | Wool |
|---|---|---|---|---|---|---|
| 0.5% | 4/5 | 4 | 4/5 | 4/5 | 5 | 5 |
| 1.0% | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.2% | 4/5 | 3/ 4 | 4/5 | 4/5 | 4/5 | 4/5 |

Table 4: Assessment color fastness to Perspiration for 60° 60 '

| Shade% | Diacetate | Bleached cotton | Polyamide | Polyester | Acrylic | Wool |
|---|---|---|---|---|---|---|
| 0.5% | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.0% | 4/5 | 3/4 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.2% | 4/5 | 3/ 4 | 4/5 | 4/5 | 4/5 | 4/5 |

Table 5: Assessment color fastness to Perspiration for 60° 40 '

| Shade% | Diacetate | Bleached cotton | Polyamide | Polyester | Acrylic | Wool |
|---|---|---|---|---|---|---|
| 0.5% | 4/5 | 4/5 | 4/5 | 4/5 | 5 | 5 |
| 1.0% | 4/5 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |
| 1.2% | 4/5 | 3/ 4 | 4/5 | 4/5 | 4/5 | 4/5 |

## Rubbing fastness test

Table 6: Assessment color fastness to rubbing

| Shade | Type | Rating Bleached cotton |
|---|---|---|
| 0.5% | Dry | 4/ 5 |
| | Wet | 4 |
| 1.0% | Dry | 4/ 5 |
| | Wet | 3/4 |
| 1.2% | Dry | 4/5 |
| | Wet | 3/ 4 |

It is noticed from the tables that the Avitera reactive dyed samples receive better fastness values for 0.5%, 1.0% and 1.2% shades. This can be explained in this way that Avitera reactive dye has more scopes for being attached with cotton fiber, thus color fastness properties are always higher in rating.

## Comparision between latest Avitera and conventional reactive dye

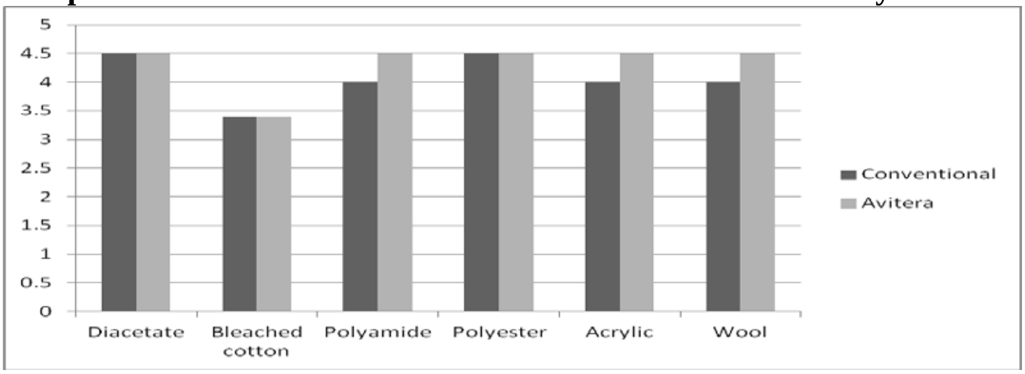



Fig 5: Comparison between Avitera and Conventional reactive dye (color fastness to perspiration)

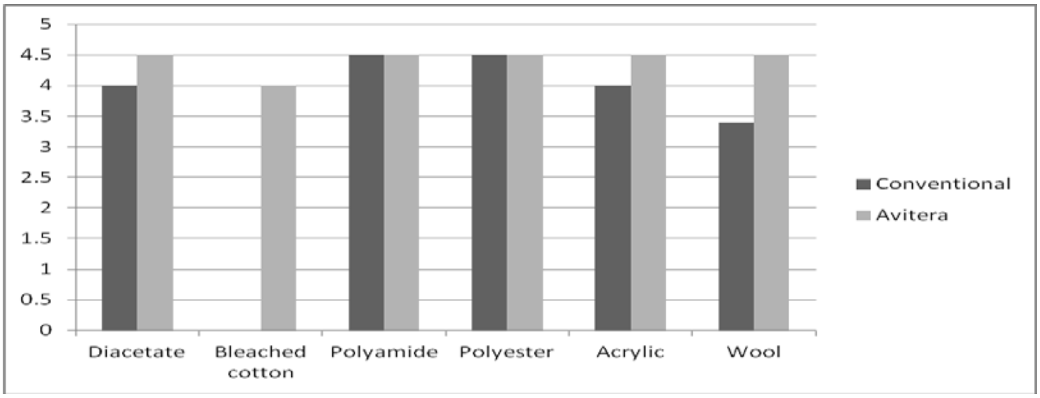



Fig 6: Comparison between Avitera and Conventional reactive dye (color fastness to wash)

It is observed from the figures 5 and 6 that the conventional reactive dyed samples take in less fastness values than Avitera reactive dyed samples. This is because that Avitera reactive dye has more reactivity for being attached with cotton fiber, thus color fastness properties are always inspiring.

**Determination of CMC DE**

Table 7: Comparative CMC value of Reactive dyed samples for 1% and 2% shades

| Shade % | DL* | Da* | Db* | CMC DE | Light source: $D_{65}$ Viewing geometry: 10 Deg. |
|---|---|---|---|---|---|
| 1% shade | -6.98 | 4.65 | -0.33 | 3.22 | |
| 2% shade | -2.84 | 5.61 | 0.35 | 2.59 | |

From table 7, it can be experienced that the CMC value of 1 % dye ( Conventional and Avitera Reactive Dye) is 3.22. The significant CMC DE indicates that the absorbency of dye is clearly higher in case of avitera dyed sample which is already stated in K/S value measurement. In the same way the CMC DE value for 2 % shade is shown as 2.59 which is also greater enough from 1 (pass value). It is obvious that 1% shade provides higher color difference than 2 % shade. The reason behind could be that the higher depth of shade was less capable of rendering much difference in dye absorption for Avitera dyes.

**Determination of CMC Da***

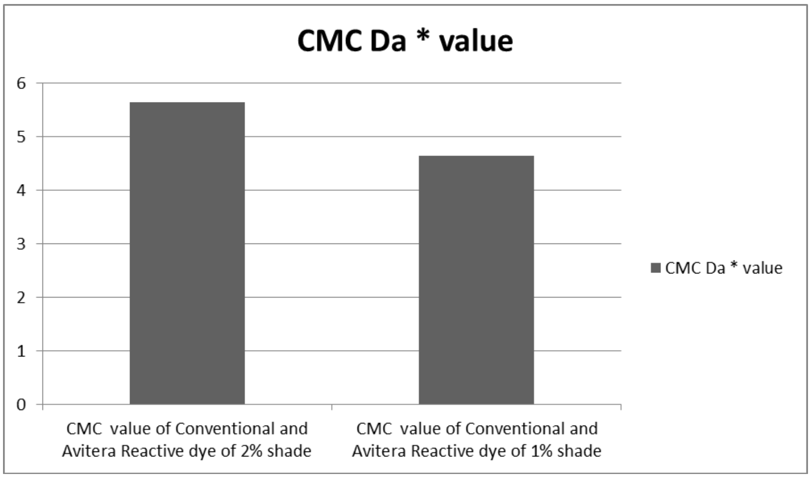



Fig 7: Comparative CMC value of Conventional and Avitera Reactive dyed samples

Figure 7 illustrates that the Da* value for 2% shade (5.61) is higher than that of 1 % shade (4.65). It is very common that higher depth of shade in single shade (Red) dyeing definitely should render greater reddish value.

**Measurement of Reflectance (R%):**

The figures 8 and 9 demonstrates that in case of lighter shade like 1%, the reflectance value is higher for both type of dyes (Conventional and Avitera). noteworthy incase of 1% shade.

This can be explained from higher deviation in CMC value for 1 % shade of the dyes.

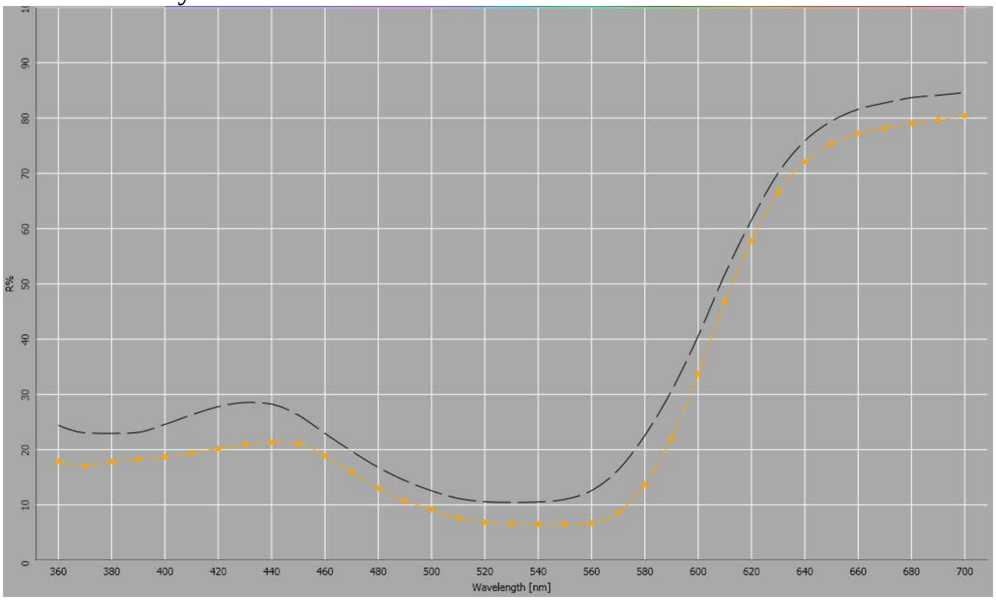



Fig 8: Comparative R% value of Conventional and Avitera Reactive dye of 1% shade

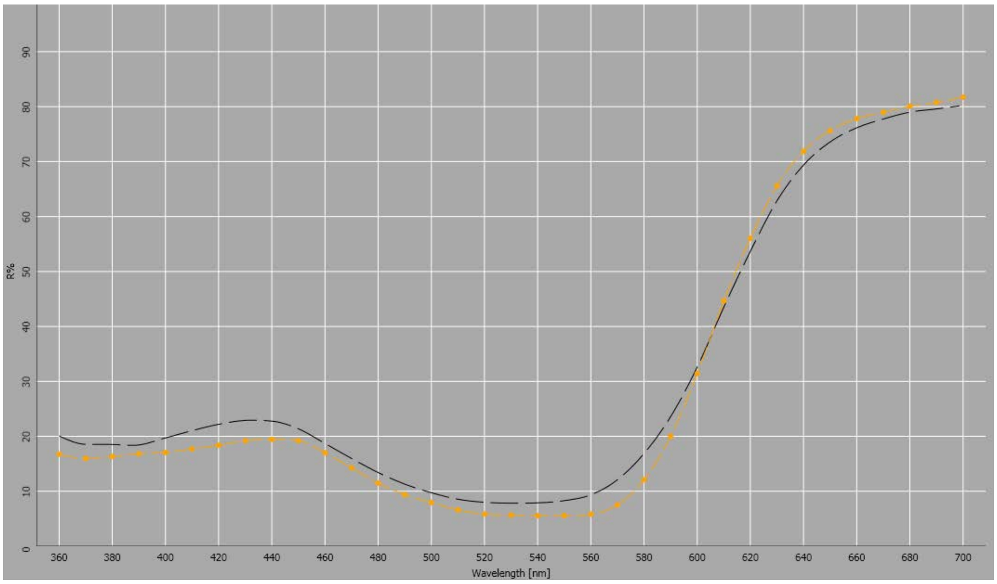



Fig 9: Comparative R% value of Conventional and Avitera Reactive dye of 2% shade

**Measurement of K/S Value:**

It is observed from the figures 10 and 11 that that the conventional reactive dyed fabric encompasses less K/S value than Avitera reactive dyed sample for both 1% and 2% shade. This is because Avitera reactive dye has more reactivity for being attached with cotton fiber.

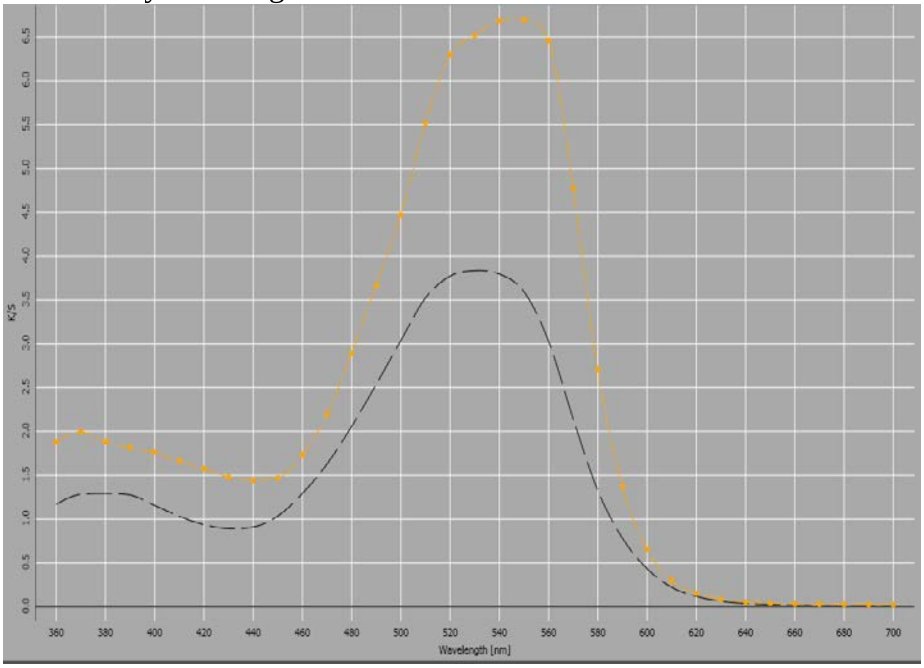



Fig. 10: Comparative K/S value of Conventional and Avitera Reactive dye of 1% shade

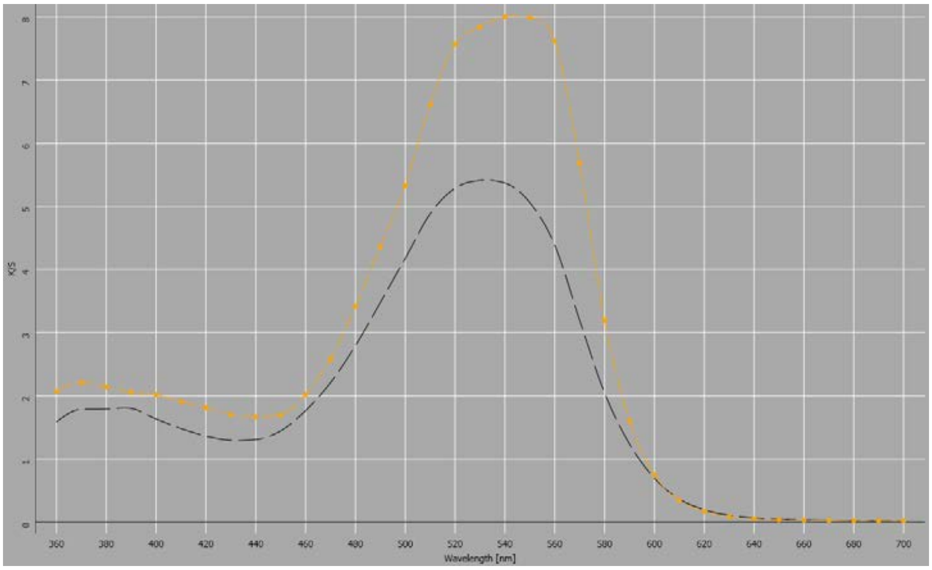



Fig. 11: Comparative K/S value of Conventional and Avitera Reactive dye of 2% shade

## Conclusion:

By implementing an experimental observation at last we came into view that the latest Avitera reactive dye has better fastness properties than conventional reactive dye which is always hunted. Moreover there is no need of adding extra chemicals like previous and it is cost-effective & eco-friendly. The research has been carried out only for cotton fabric, and that could be done on other types of fibres also. Resultant outcomes are experienced as increasing the robustness of individual dyes and dye combinations in tri-chromatic systems, enhancing reproducibility of tri-chromatic combinations used in most commonly applied dyeing processes, reducing salt consumption and unused dye in the effluent, improving fastness properties (e.g.:- light fastness, fastness to repeated laundering). Actually it offers poly functional dye chemistry to improve reactivity, fixation level and reproducibility. Gratitude goes to the Department of Textile Engineering of Dhaka University of Engineering & Technology for permission to use the laboratory and thus providing the opportunity to complete such a caring research work.

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